CHAPTER 2

Lacrimal Drainage System

Introduction

Applied anatomy

The lacrimal drainage system consists of the following structures (Fig. 2.1):

1. **The puncta** are located at the posterior edge of the lid margin, at the junction of the lash-bearing lateral five-sixths (pars ciliaris) and the non-ciliated medial one-sixth (pars lacrimalis) of each lid. Normally they face slightly posteriorly and can be inspected by everting the medial aspect of the lids. Treatment of excessive watering caused by punctal stenosis or malposition is relatively straightforward.
2. **The canaliculi** pass vertically from the lid margin (the ampullae) for about 2 mm. They then turn medially and run horizontally for about 8 mm to reach the lacrimal sac. The superior and inferior canaliculi most often unite to form the common canaliculus, which opens into the lateral wall of the lacrimal sac. In some individuals, each canaliculus opens separately. A small flap of mucosa (valve of Rosenmuller) overhangs the junction of the common canaliculus and the lacrimal sac and prevents reflux of tears into the canaliculi. Treatment of canalicular obstruction is frequently complicated.
3. **The lacrimal sac** is about 10 mm long and lies in the lacrimal fossa between the anterior and posterior lacrimal crests. The lacrimal bone and the frontal process of the maxilla separate the lacrimal sac from the middle meatus of the nasal cavity. In a dacryocystorhinostomy (DCR) an anastomosis is created between the sac and the nasal mucosa to bypass an obstruction in the nasolacrimal duct.
4. **The nasolacrimal duct** is about 12 mm long and is the inferior continuation of the lacrimal sac. It descends and angles slightly laterally and posteriorly to open into the inferior nasal meatus, lateral to and below the inferior turbinate. The opening of the duct is partially covered by a mucosal fold (valve of Hasner). Obstruction of the duct may cause a secondary distension of the sac.

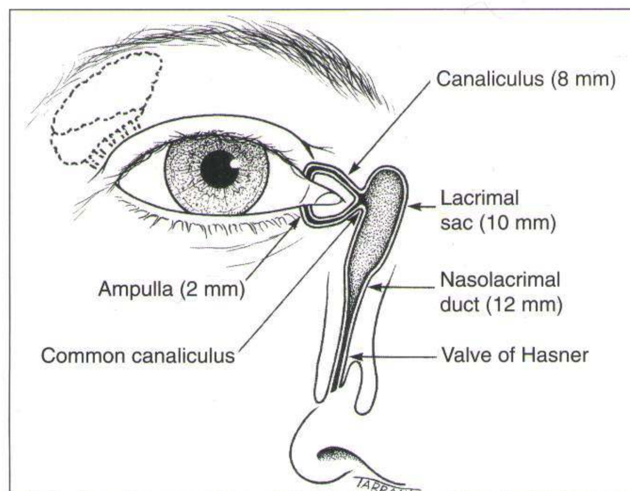


Fig. 2.1
Anatomy of the lacrimal drainage system

Applied physiology

Tears secreted by the main and accessory lacrimal glands pass laterally across the ocular surface. A variable amount of the aqueous component of the tear film is lost by evaporation. This is related to the size of the palpebral aperture, the blink rate, ambient temperature and humidity. The remainder of the tears drain as follows (Fig. 2.2):

1. Tears flow along the upper and lower marginal strips and enter the upper and lower canaliculi by capillarity and also possibly by suction. About 70% of tears drain through the lower canaliculus and the remainder through the upper (Fig. 2.2a).
2. With each blink, the pretarsal orbicularis oculi compresses the ampullae, shortens the horizontal canaliculi and moves the puncta medially (Fig. 2.2b). Simultaneously, the lacrimal part of the orbicularis oculi, which is attached to the fascia of the lacrimal sac, contracts and expands the sac, thereby creating a negative pressure which sucks the tears from the canaliculi into the sac.
3. When the eyes open the muscles relax, the sac collapses and a positive pressure is created which forces the tears

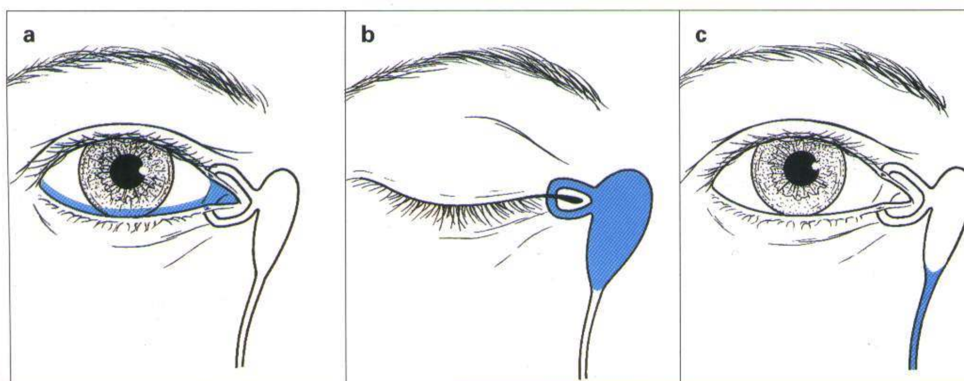


Fig. 2.2
Physiology of the lacrimal pump mechanism

down the nasolacrimal duct into the nose (Fig. 2.2c). Gravity also plays a role. The puncta move laterally, the canaliculi lengthen and fill with tears.

Causes of watering

Overflow of tears may represent lacrimation or epiphora.

1. **Lacrimation** (hyperlacrimation) is caused by reflex lacrimal hypersecretion secondary to ocular inflammation or surface disease. In these cases watering is associated with symptoms of the underlying cause and treatment is usually medical.
2. **Epiphora** is due to compromise of lacrimal drainage. It is exacerbated by a cold and windy atmosphere, and is least in a warm dry room. It may be caused by:
   a. *Malposition* of the lacrimal puncta (e.g. secondary to ectropion).
   b. *Obstruction* anywhere along the lacrimal drainage system, from the puncta to the nasolacrimal duct.
   c. *Lacrimal pump failure*, which may occur secondarily to lower lid laxity or weakness of the orbicularis muscle (e.g. facial nerve palsy).

Evaluation of the watering eye

External examination

1. **The marginal tear strip** of both eyes should be examined on the slit-lamp prior to any manipulation of the eyelids or instillation of topical medication, which may prejudice the clinical picture. Many patients with epiphora do not have obvious overflow of tears onto the face but merely show a high marginal tear strip on the affected side.
2. **The eyelids** should be examined for evidence of malposition. Perhaps the commonest cause of lid (and consequently punctal) malposition is ectropion, which may be of involutional, paralytic or cicatricial aetiology. Such ectropion may involve predominantly the pars lacrimalis. Normally the inferior lacrimal punctum is apposed to the globe and not visible without everting the lower lid. A rare cause of epiphora is the *Centurion syndrome*. Patients with this condition manifest epiphora from childhood secondary to anterior malposition of the medial part of the lid with displacement of puncta out of the lacus lacrimalis due to a prominent nasal bridge (Fig. 2.3). Occasionally epiphora may be caused by a large caruncle displacing the inferior punctum away from the globe (Fig. 2.4) or obstruction of the inferior punctum by a fold of redundant conjunctiva (conjunctivochalasis).
3. **The dynamics of eyelid closure** should be evaluated. Normally, the lid margins approximate and the puncta are apposed when the eyes close. In patients with lower lid laxity, one lid may over-ride the other or the puncta may evert (Fig. 2.5).

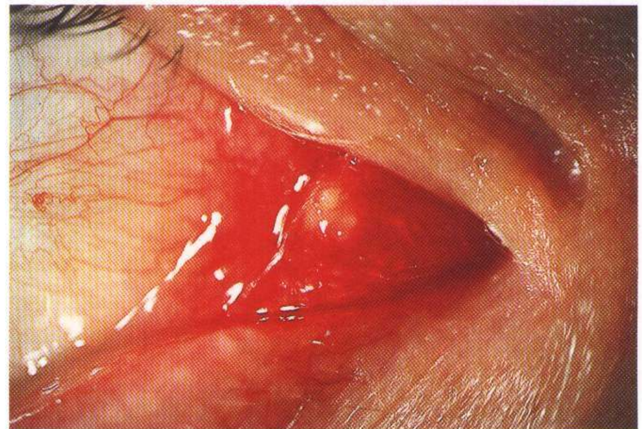


Fig. 2.4
Large caruncle displacing the inferior punctum



Fig. 2.3
Centurion syndrome



Fig. 2.5
Right upper lid over-riding the lower

4. **The puncta** are best examined on the slit-lamp. Apart from malposition, the puncta may be inflamed, stenosed (Fig. 2.6) or obstructed, sometimes by an eyelash (Fig. 2.7). Canaliculitis is characterized by pouting of the punctum (Fig. 2.8) and expression of pus or concretions on manual canalicular compression with a glass rod. Abnormal findings in children include punctal agenesis, accessory puncta (Fig. 2.9) or a congenital lacrimal fistula.


Fig. 2.6
Punctal stenosis associated with mild ectropion

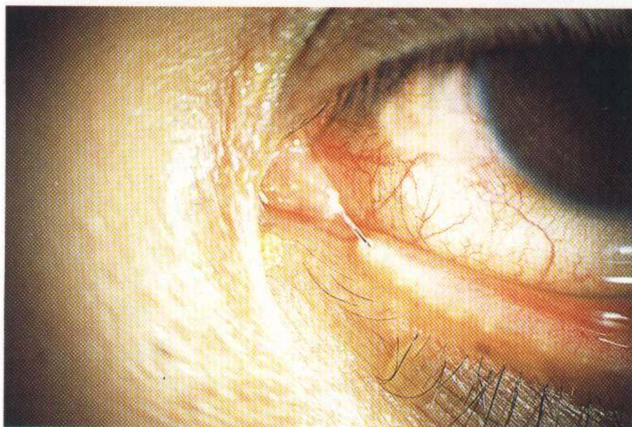

Fig. 2.7
Punctal obstruction by an eyelash


Fig. 2.8
Pouting punctum in chronic canaliculitis


Fig. 2.9
Accessory punctum


Fig. 2.10
Expression of mucopurulent material

5. **The lacrimal sac** should then be palpated. Punctal reflux of mucopurulent material on lacrimal compression (Fig. 2.10) is indicative of a mucocele with a patent canalicular system, but with an obstruction either at, or distal to, the lower end of the lacrimal sac. In acute dacryocystitis palpation is severely painful and compression should be avoided. Occasionally, palpation of the sac will reveal a stone or a tumour.
6. **Fluorescein retention test** (fluorescein disappearance test) is performed by instilling fluorescein 2% drops into both conjunctival fornices. Normally, little or no dye remains after 3 minutes. Prolonged retention is indicative of inadequate lacrimal drainage and can be graded from 1 to 4 (Fig. 2.11).

Probing and irrigation

This is performed only after ascertaining punctal patency. Under topical anaesthesia, a gently curved, blunt tipped



Fig. 2.11
Prolonged retention of fluorescein-stained tears

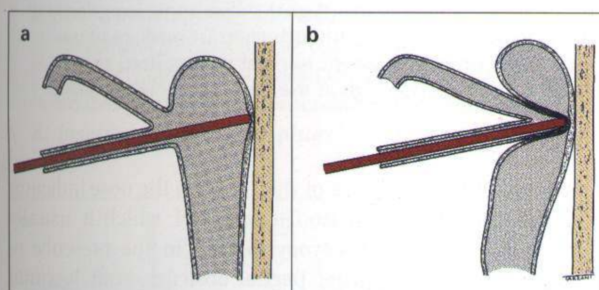


Fig. 2.12
(a) Hard stop; (b) soft stop

lacrimal cannula on a 2 ml saline-filled syringe is inserted into the lower punctum and advanced, following the contour of the canaliculus. An attempt is made to enter the lacrimal sac, the medial wall of which lies against the bone of the lacrimal fossa. The cannula can come either to a hard stop or to a soft stop.

1. **A hard stop** occurs if the cannula enters the lacrimal sac. It comes to a stop at the medial wall of the sac, through which can be felt the rigid lacrimal bone (Fig. 2.12a). This excludes complete obstruction of the canalicular system. The examiner places one finger over the lacrimal fossa and irrigates. If the saline passes into the nose the patient has a patent lacrimal drainage system, which may, however, be stenosed; alternatively there may be subtle lacrimal pump failure. Failure of saline to reach the nose is indicative of total obstruction of the nasolacrimal duct. In this situation, the lacrimal sac will become distended during irrigation and there will also be reflux through the upper punctum. The regurgitated material may be clear, mucoid, mucopurulent or frankly purulent, depending on the contents of the lacrimal sac.
2. **A soft stop** is experienced if the cannula stops at or proximal to the junction of the common canaliculus and the lacrimal sac, i.e. at the lateral wall of the sac. The sac is thus not entered—a spongy feeling is experienced as the cannula presses the soft tissue of the common canaliculus and the lateral wall against the medial wall of the sac and the lacrimal bone behind it (Fig. 2.12b). Irrigation will therefore not cause the sac to distend. In the case of lower canalicular obstruction, there will be reflux of saline through the lower punctum. Reflux through the upper punctum indicates patency of both upper and lower canaliculi, but obstruction of the common canaliculus.

Jones dye testing

This is only indicated in patients with suspected partial obstruction of the drainage system. These patients manifest epiphora, but the lacrimal system can be successfully syringe irrigated. Dye testing is of no value in the context of total obstruction.

1. **The primary test** (Fig. 2.13a) differentiates partial obstruction of the lacrimal passages from primary hypersecretion of tears. First, a drop of 2% fluorescein is instilled into the conjunctival sac. After about 5 minutes, a cotton-tipped bud moistened in a local anaesthetic is inserted under the inferior turbinate at the nasolacrimal duct opening. The results are interpreted as follows:
   a. ***Positive:*** fluorescein recovered from the nose indicates patency of the drainage system. Watering is due to primary hypersecretion and no further tests are necessary.
   b. ***Negative:*** no dye recovered from the nose indicates a partial obstruction (site unknown) or failure of the

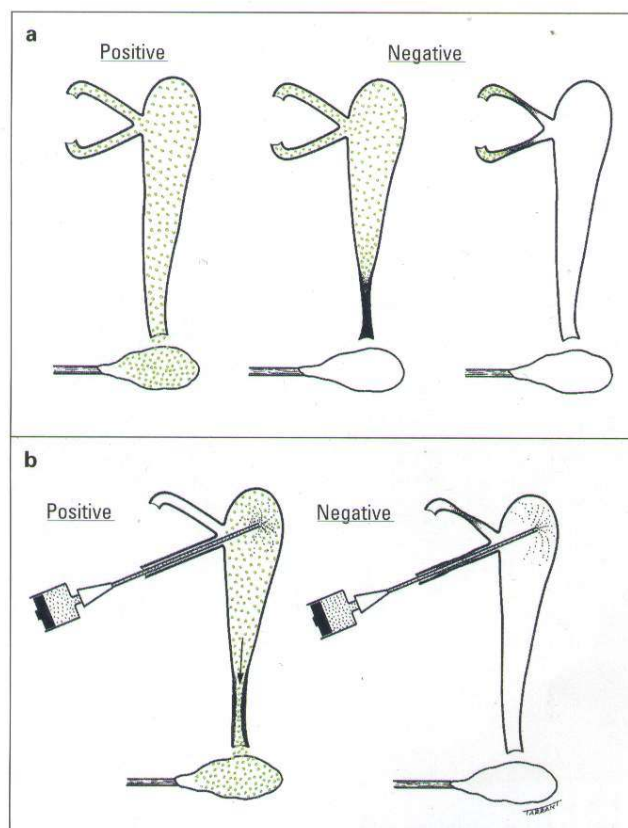


Fig. 2.13
Jones dye testing. (a) primary; (b) secondary

lacrimal pump mechanism. In this situation the secondary dye test is performed immediately.

> *NB:* 22% of normal individuals manifest a negative primary Jones test.

2. **The secondary (irrigation) test** (Fig. 2.13b) identifies the probable site of partial obstruction, on the basis of whether the topical fluorescein instilled for the primary test entered the lacrimal sac. Topical anaesthetic is instilled and any residual fluorescein washed out. The drainage system is then irrigated with saline with a cotton-tipped bud under the inferior turbinate.
   a. *Positive:* fluorescein-stained saline recovered from the nose indicates that fluorescein entered the lacrimal sac, thus confirming functional patency of the upper lacrimal passages. Partial obstruction of the naso-lacrimal duct is inferred.
   b. *Negative:* unstained saline recovered from the nose indicates that fluorescein did not enter the lacrimal sac. This implies partial obstruction of the upper lacrimal passages (puncta, canaliculi or common canaliculus) or a defective lacrimal pump mechanism.

Contrast dacryocystography

1. **Technique**
   a. The inferior puncta are dilated with a Nettleship punctum dilator.
   b. Plastic catheters are inserted into the inferior canaliculi on either side (alternatively the upper puncta may be used).
   c. Contrast medium, usually 1 ml of Lipiodol, is simultaneously injected on both sides and postero-anterior radiographs are taken (Figs 2.14, 2.15).
   d. Five minutes later an erect oblique film is taken to assess the effect of gravity on tear drainage.

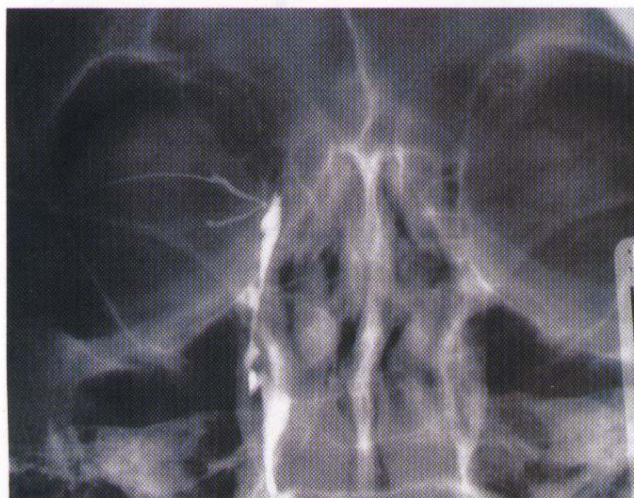


Fig. 2.14
Right dacryocystogram showing free flow of contrast medium into the nose despite mild stenosis of the common canaliculus (Courtesy of R. Welham)

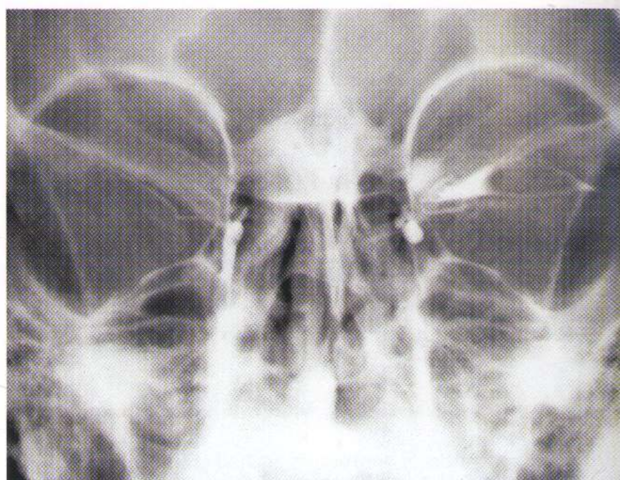


Fig. 2.15
Bilateral dacryocystogram. **(Right)** shows some irregularity of the common canaliculus, although contrast medium passes through an otherwise patent lacrimal system; **(left)** shows complete obstruction high in the sac (Courtesy of R. Welham)

2. **Interpretation**. Failure of dye to reach the nose indicates an anatomical obstruction, the site of which is usually evident. A normal dacryocystogram in the presence of epiphora indicates either partial obstruction or lacrimal pump failure. Dacryocystography is also helpful in the diagnosis of diverticula, fistulae and filling defects caused by stones or tumours.

Lacrimal scintillography

This is a sophisticated test which assesses tear drainage under more physiological conditions than dacryocystography. Although it does not provide the same detailed anatomical visualization as dacryocystography, it is more sensitive in assessing incomplete blocks, especially in the upper part of the lacrimal system. The test is performed as follows:

a. Radionuclide technetium-99 is delivered by a micropipette to the lateral conjunctival sac as a 10 μl drop. The tears are thus labelled with this gamma-emitting radioactive substance.
b. The tracer is imaged by a gamma camera focused on the inner canthus and a sequence of images is recorded over 20 minutes.

Obstruction of lacrimal drainage

Acquired obstruction

Primary punctal stenosis

This occurs in the absence of punctal eversion.

1. **Causes**
   - Idiopathic primary stenosis is by far the most common.
   - Herpes simplex lid infection.
   - Following irradiation of malignant lid tumours.
   - Cicatrizing conjunctivitis and trachoma.
   - Systemic cytotoxic drugs such as 5-fluorouracil and docetaxel.
2. **Treatment** is initially by dilatation of the punctum with a Nettleship dilator (Fig. 2.16). If repeated dilatation is unsuccessful one of the following procedures may be considered:
   a. One-snip ampullotomy, in which a vertical 2 mm snip is made in the posterior wall of the ampulla.
   b. Two-snip procedure in which both a vertical and a small horizontal cut is made in the ampulla (Fig. 2.17). This yields a larger (Fig. 2.18) and more permanent opening than a one-snip procedure.
   c. Laser punctoplasty in which the punctum is opened with an argon laser. This method is particularly useful in elderly patients in whom the punctum is occluded by an overgrowth of conjunctival epithelium.
   d. Insertion of canalized plugs into the inferior punctum.

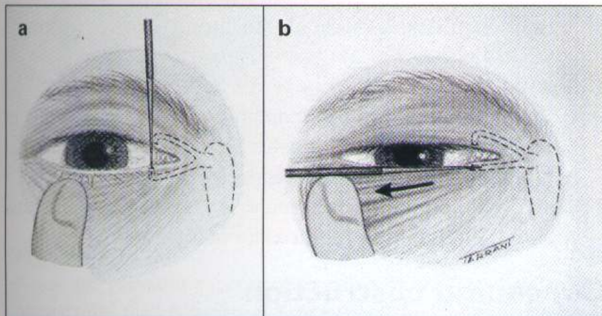


Fig. 2.16
Technique of dilating the inferior punctum

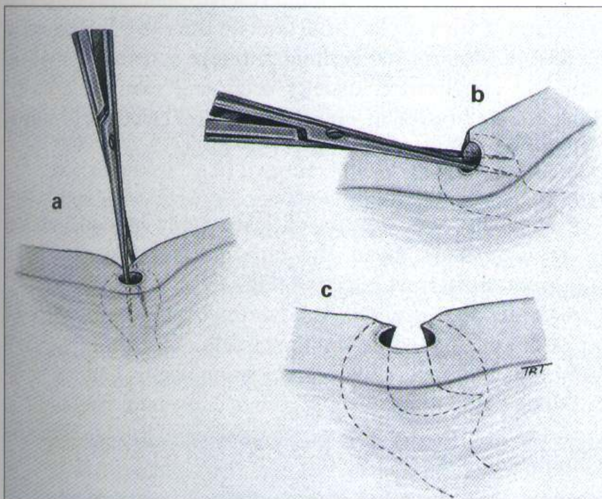


Fig. 2.17
Two-snip procedure for punctal stenosis. (**a**) Vertical cut; (**b**) horizontal cut; (**c**) final result



Fig. 2.18
Appearance following a two-snip procedure

Secondary punctal stenosis

This occurs secondary to punctal eversion (*see* Fig. 2.6). Treatment of pure punctal eversion, unassociated with significant involutional ectropion, is by one of the following:

a. Ziegler cautery burns are applied to the palpebral conjunctiva, 5 mm below the punctum. Subsequent shrinkage of the cauterized tissue (cicatrization) should invert the punctum.

b. Medial conjunctivoplasty involves excision of a diamond-shaped piece of tarsoconjunctiva, about 4 mm high and 8 mm wide, parallel with and inferior to the canaliculus and punctum, followed by approximation of the superior and inferior wound margins with sutures (Fig. 2.19). Incorporation of the lower lid retractors in the sutures further aids punctal inversion. Once the punctum is restored to its normal position, it is dilated so that it may remain open when normal tear flow is established. If stenosis recurs, treatment is the same as for primary stenosis.

Canalicular obstruction

1. **Causes** are similar to those of primary punctal obstruction.

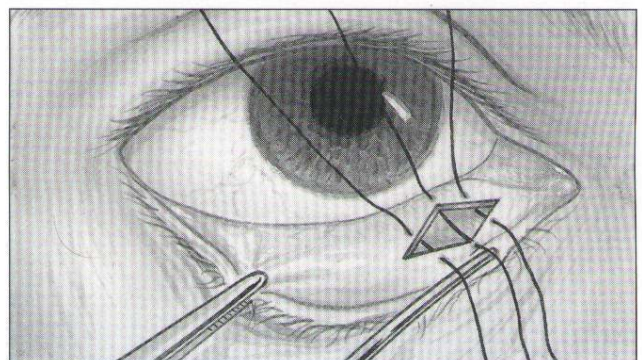


Fig. 2.19
Medial conjunctivoplasty

2. **Treatment** depends on the site and degree of obstruction.
   a. ***Partial*** obstruction of the common or individual canaliculi, or indeed anywhere in the nasolacrimal drainage system, may be treated by intubation. Two ends of a length of silicone tubing are threaded via the superior and inferior puncta, through the lacrimal sac down to the nose, where they are tied (or secured with a special (Watzke) sleeve) and left in situ for 3–6 months (Fig. 2.20).
   b. ***Total individual canalicular obstruction***, with at least 8 mm of patent normal canaliculus between the punctum and obstruction, is treated by anastomosis of the patent part of the canaliculus into the lacrimal sac (canaliculodacryocystorhinostomy—CDCR) and intubation. When the block is less than 8 mm from the punctum treatment involves conjunctivodacryocystorhinostomy and the insertion of a special (Lester Jones) tube (*see* below).
   c. ***Total obstruction of the lateral end*** of the common canaliculus is usually caused by idiopathic pericanalicular fibrosis, in which the entire common canaliculus is obstructed. Dacryocystography will obviously show failure of filling of the common canaliculus. Treatment involves resection of the obstructed common canaliculus and CDCR. The lacrimal system is then intubated for 3–6 months.
   d. ***Total obstruction of the medial end*** of the common canaliculus is often caused by a thin membrane at its junction with the lumen of the sac, often secondary to chronic dacryocystitis. Dacryocystography will show filling of the common canaliculus. This is treated by DCR and excision of the membrane from its sac aspect (*see* below). The lacrimal system is then intubated for 3–6 months.

Nasolacrimal duct obstruction

1. **Causes**
   - Idiopathic stenosis is by far the most common.
   - Naso-orbital trauma.

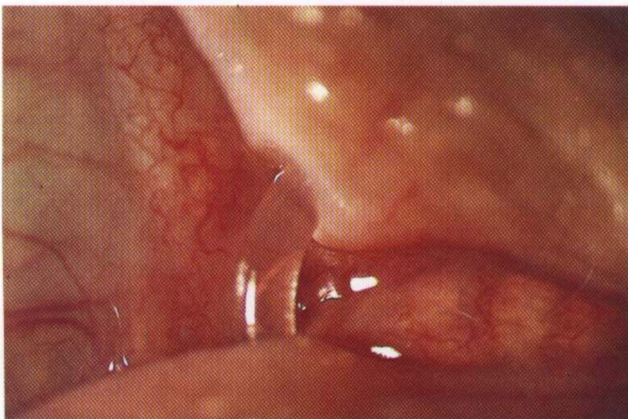


Fig. 2.20
Silicone tube in situ

   - Wegener granulomatosis.
   - Infiltration by nasopharyngeal tumours.
2. **Treatment** depends on the completeness of obstruction as follows:
   a. ***Complete obstruction*** is treated by DCR.
   b. ***Incomplete obstruction*** may respond to intubation of the lacrimal system with silicone tubes or stents. This should only be performed if the tubes or stents can be passed easily, otherwise a DCR should be done. Some cases may benefit from balloon dilatation (*see* below).

Dacryolithiasis

Dacryoliths (lacrimal stones) may occur in any part of the lacrimal system, more commonly in males. Although the pathogenesis is unclear, it has been proposed that tear stagnation secondary to inflammatory obstruction may precipitate dacryolith formation and squamous metaplasia of the lacrimal sac epithelium.

1. **Presentation**
   - Dacryoliths are often asymptomatic and may be discovered at the time of DCR.
   - Symptomatic patients usually present in late adulthood in a variety of ways including intermittent epiphora, recurrent attacks of acute dacryocystitis and lacrimal sac distension.
2. **Signs**
   - The lacrimal sac is distended and relatively firm, but is not inflamed and tender as in acute dacryocystitis.
   - Mucus reflux on pressure may or may not be present.
3. **Treatment** involves massage, lacrimal irrigation and probing; DCR may be required for complete obstruction.

Congenital obstruction

Nasolacrimal duct obstruction

This is perhaps better termed delayed canalization of the nasolacrimal duct, since it often resolves spontaneously. The lower end of the nasolacrimal duct (at the valve of Hasner) is the last portion of the lacrimal drainage system to canalize, complete canalization usually occurring soon after birth. However, up to 20% of children manifest evidence of nasolacrimal obstruction in the first year of life.

1. **Signs**
   - Epiphora and matting of lashes may be constant or intermittent when the child has a cold or upper respiratory tract infection (Fig. 2.21).
   - Gentle pressure over the lacrimal sac causes reflux of purulent material from the puncta.
   - Acute dacryocystitis is uncommon (Fig. 2.22).
2. **Differential diagnosis** of other congenital causes of a watering eye include punctal atresia and fistulae between the sac and skin.

> ***NB:*** It is important to exclude congenital glaucoma in an infant with a watering eye.

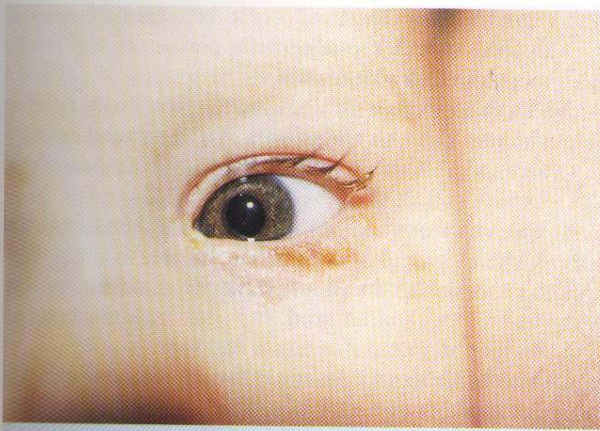


Fig. 2.21
Sticky eye due to delayed canalization of the nasolacrimal duct



Fig. 2.22
Acute dacryocystitis secondary to delayed canalization of the nasolacrimal duct (Courtesy of R. Welham)

3. Treatment

a. Massage of the lacrimal sac increases the hydrostatic pressure and may rupture the membranous obstruction. In performing this manoeuvre, the index finger is placed over the common canaliculus to block reflux through the puncta and then massaged firmly downwards. Ten strokes should be applied four times a day. Massage should be accompanied by lid hygiene; however, topical antibiotics should be reserved for superadded bacterial conjunctivitis, which is surprisingly uncommon.

b. Probing of the lacrimal system should be delayed until the age of 12 months because spontaneous canalization occurs in about 95% of cases. Probing performed within the first 2 years of life has a very high success rate, but thereafter the efficacy decreases. It should be carried out under a general anaesthetic and preferably through the upper punctum (Fig. 2.23). The rationale is to manually overcome the obstructive membrane at the Hasner valve. After probing, the lacrimal system is irrigated with saline labelled with fluorescein. If fluorescein can be recovered by aspiration from the pharynx, successful probing is confirmed. Postoperative

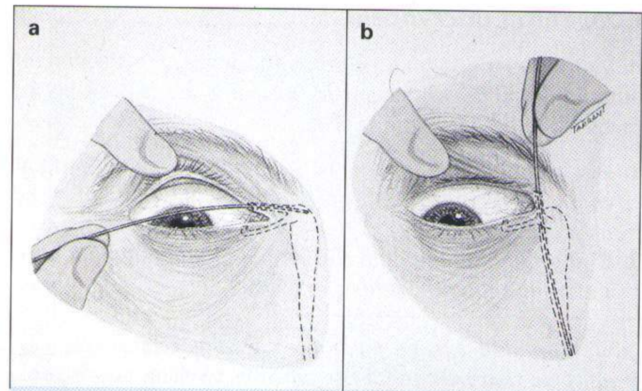


Fig. 2.23
Technique of probing of the nasolacrimal duct

antibiotic drops are used q.i.d. for 1 week. If, after 6 weeks, there is no improvement, probing should be repeated. Nasal endoscopic monitoring of probing is recommended, especially for repeated probing, to detect anatomical abnormalities and ensure correct probe position.

4. Results. Ninety per cent of children are cured by the first probing and a further 6% by the second. Failure is usually the result of abnormal anatomy, which can usually be recognized by difficulty in passing the probe and subsequent non-patency of the lacrimal drainage system on irrigation. If symptoms persist despite two technically satisfactory probings, temporary intubation with fine silastic tubes or balloon dilatation of the nasolacrimal duct may effect a cure. Patients who fail to respond to such measures can be treated with DCR performed between the ages of 3 and 4 years, provided the obstruction is distal to the lacrimal sac.



Fig. 2.24
Amniontocele (Courtesy of R. Welham)

Congenital dacryocele

A congenital dacryocele (amniontocele) is a collection of amniotic fluid or mucus in the lacrimal sac caused by an imperforate Hasner valve.

1. **Presentation** is perinatal with a bluish cystic swelling at or below the medial canthal area, accompanied by epiphora (Fig. 2.24).
2. **Signs**. A tense lacrimal sac which is initially filled with mucus but may become secondarily infected.

> *NB:* It should not be mistaken for an encephalocele, which is characterized by a pulsatile swelling above the medial canthal tendon.

3. **Treatment** is initially conservative but if this fails probing should not be delayed.

Principles of lacrimal surgery

Conventional DCR

This is indicated for obstruction beyond the medial opening of the common canaliculus (i.e. the canalicular system is patent). In principle this operation involves anastomosing the lacrimal sac to the nasal mucosa of the middle nasal meatus. The procedure is performed under general hypotensive anaesthesia.

1. **Technique**
   a. The middle nasal mucosa is packed with sterile ribbon gauze soaked in 2% lignocaine with 1:200,000 adrenaline, to achieve vasoconstriction of the mucosa.
   b. A straight vertical incision is made 10 mm medial to the inner canthus, avoiding the angular vein (Fig. 2.25a).
   c. The anterior lacrimal crest is exposed by blunt dissection and the superficial portion of the medial palpebral ligament divided.
   d. The periosteum is divided from the spine on the anterior lacrimal crest to the fundus of the sac and reflected forwards. The sac is reflected laterally from the lacrimal fossa (Fig. 2.25b).
   e. The anterior lacrimal crest and the bone from the lacrimal fossa are removed (Fig. 2.25c).
   f. A probe is introduced into the lacrimal sac through the lower canaliculus and the sac is incised in an 'H-shaped' manner to create two flaps.
   g. A vertical incision is made in the nasal mucosa to create anterior and posterior flaps (Fig. 2.25d).
   h. The posterior flaps are sutured (Fig. 2.25e).
   i. The anterior flaps are sutured (Fig. 2.25f).
   j. The medial canthal tendon is resutured to the periosteum and the skin incision closed with interrupted sutures.
2. **Results** in experienced hands are excellent with a success rate of over 90%.
3. **Causes of failure** include inadequate size and position of the ostium, unrecognized common canalicular obstruction, scarring and the 'sump syndrome', in which the surgical opening in the lacrimal bone is too small and too high. There is thus a dilated lacrimal sac lateral to and below the level of the inferior margin of the ostium, in which secretions collect, unable to gain access to the ostium and thence the nasal cavity.
4. **Potential complications** include cutaneous scarring, injury to medial canthal structures, haemorrhage, cellulitis and cerebrospinal fluid rhinorrhoea, if the subarachnoid space is inadvertently entered.

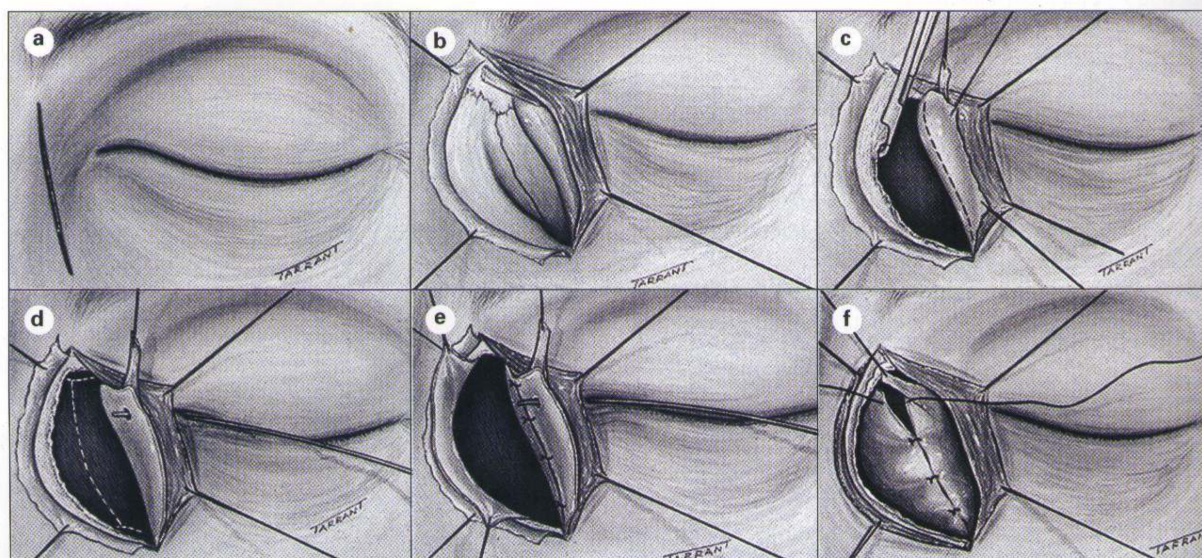


Fig. 2.25
Technique of dacryocystorhinostomy (*see* text)

Endoscopic DCR

This may be considered for obstruction beyond the medial opening of the common canaliculus, particularly following failed conventional DCR. The procedure can be performed either under general anaesthesia (without hypotension) or local anaesthesia. Advantages over conventional DCR include the lack of skin incision, shorter operating time, lower risk of interfering with the physiological lacrimal pump mechanism, minimal blood loss and no risk of cerebrospinal fluid rhinorrhoea.

1. **Technique**. A slender light pipe is passed through the lacrimal puncta and canaliculi into the lacrimal sac and viewed from within the nasal cavity with an endoscope. The remainder of the procedure is performed from within the nasal cavity.
   a. The mucosa over the frontal process of the maxilla is stripped.
   b. A part of the nasal process of the maxilla is removed.
   c. The lacrimal bone is broken off piecemeal.
   d. The lacrimal sac is opened.
   e. Silicone tubes are passed through the upper and lower puncta, pulled out through the ostium and tied within the nose.
2. **Results**. The success rate is about 85%.

Endolaser DCR

Performed with a holmium:YAG laser, this is a quick procedure which can be carried out under local anaesthesia. It is therefore particularly suitable for elderly patients. The success rate is only about 70% but because normal anatomy is not disrupted it does not prejudice subsequent surgical intervention in the cases that fail.

Lester Jones tube

Insertion of a Lester Jones tube is indicated when there is absence of canalicular function, either due to obstruction less than 8 mm from the puncta, or due to lacrimal pump failure.

a. A DCR is performed as far as suturing the posterior flaps.
b. The caruncle is partially excised.
c. A stab incision is made with a Graefe knife from a point about 2 mm behind the inner canthus (under the former caruncle) in a medial direction, so that the tip of the knife emerges just behind the anterior flap of the lacrimal sac (Fig. 2.26a).
d. The tract is enlarged sufficiently with a microtrephine to allow the introduction of a polythene tube (Fig. 2.26b).
e. The incision is sutured as for a DCR.
f. After 2 weeks the polythene tube is replaced by a glass tube.

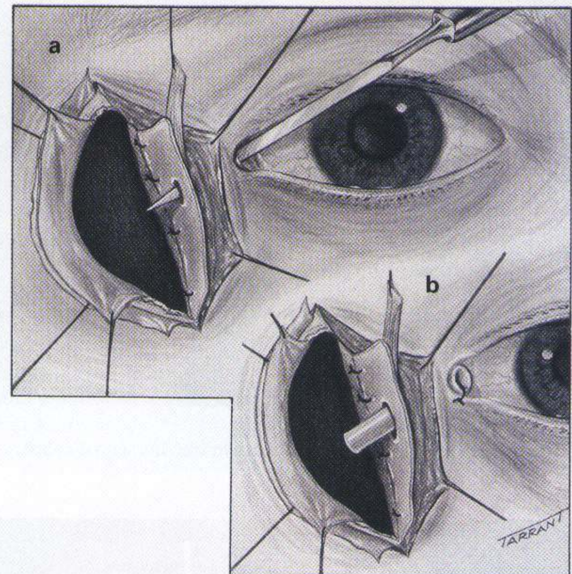


Fig. 2.26
Technique of Lester Jones tube insertion (see text)

Balloon dacryocystoplasty

This may be a satisfactory primary treatment for adults with partial nasolacrimal duct obstruction who do not exhibit signs of chronic infection.

Infections of lacrimal passages

Chronic canaliculitis

Chronic canaliculitis is an uncommon condition, frequently caused by *Actinomyces*, which are anaerobic Gram-positive bacteria. While a diverticulum or obstruction of the canaliculus can promote anaerobic bacterial growth secondary to stasis, in most cases there is no identifiable predisposition.

1. **Presentation** is with unilateral epiphora associated with chronic mucopurulent conjunctivitis, refractory to conventional treatment.
2. **Signs**
   - Pericanalicular inflammation is characterized by oedema of the canaliculus (Fig. 2.27) and a 'pouting' punctum best seen with the slit-lamp (Fig. 2.28).
   - Concretions consisting of sulphur granules are expressed on canalicular compression with a glass rod (Fig. 2.29).

> ***NB:*** In contrast to dacryocystitis, there is no nasolacrimal duct obstruction, lacrimal sac distension or inflammation.

3. **Treatment**
   *a. **Topical antibiotics*** such as ciprofloxacin q.i.d. for 10 days may be tried initially but are rarely curative.


Fig. 2.27
Oedema of the left upper canaliculus in chronic canaliculitis

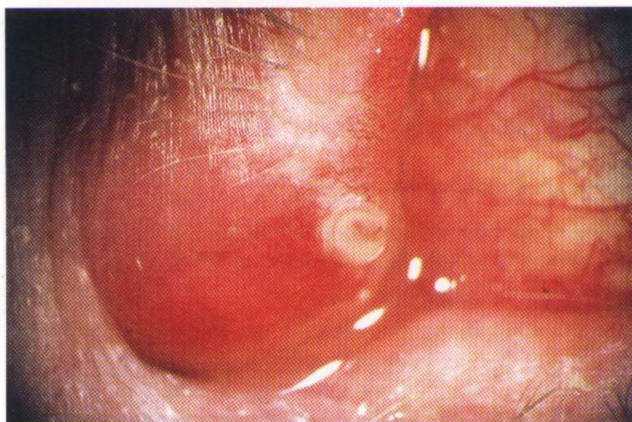
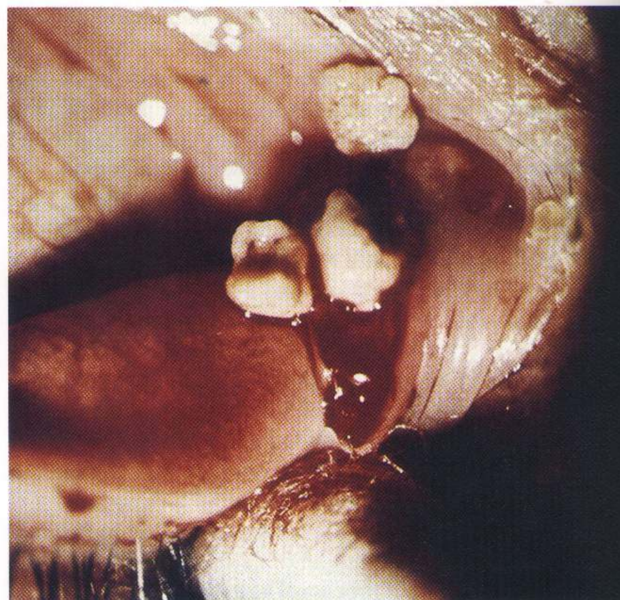

Fig. 2.28
Pouting of the punctum in chronic canaliculitis


Fig. 2.29
Expressed concretions in chronic canaliculitis

b. *Canaliculotomy* (Fig. 2.30) involving a linear incision into the conjunctival side of the canaliculus is the most effective treatment, although occasionally it may result in scarring and interference with canalicular function.


Fig. 2.30
Exposure of large concretions following canaliculotomy in chronic canaliculitis

Dacryocystitis

Infection of the lacrimal sac is usually secondary to obstruction of the nasolacrimal duct. It may be acute or chronic and is most commonly caused by staphylococci.

Acute dacryocystitis

1. **Presentation** is with subacute onset of pain, redness and swelling at the medial canthus and epiphora.


Fig. 2.31
Acute dacryocystitis

2. **Signs**. A very tender, red, tense swelling at the medial canthus which may be associated with preseptal cellulitis in severe cases (Fig. 2.31).
3. **Treatment**
   a. ***Initial*** treatment involves the application of local warmth and oral antibiotics such as flucloxacillin.

> ***NB:*** Irrigation and probing should not be performed.

   b. ***Incision and drainage***. The infection may sometimes extend outside the sac to produce an abscess in the perilacrimal soft tissue (lacrimal abscess). If pus points and the abscess threatens to drain spontaneously (Fig. 2.32), incision and drainage may be considered. This, however, carries a risk of the development of a lacrimal fistula, which may serve as a conduit for tears from the lumen of the lacrimal sac to the skin surface.
   c. ***DCR*** is usually necessary after the acute infection has been controlled and should not be delayed because of the risk of recurrent infection.


Fig. 2.32
Lacrimal sac abscess


Fig. 2.33
Mucocele

Chronic dacryocystitis

1. **Presentation** is with epiphora which may be associated with a chronic or recurrent unilateral conjunctivitis.
2. **Signs**. A painless swelling at the inner canthus caused by a mucocele (Fig. 2.33). Obvious swelling may be absent, although pressure over the sac commonly still results in reflux of mucopurulent material through the canaliculi (*see* Fig. 2.10).

> ***NB:*** It is often wise to postpone intraocular surgery until lacrimal infection has been treated, owing to the grave risk of endophthalmitis.

3. **Treatment** is with DCR.

CHAPTER 3

The Dry Eye

Applied physiology

The main lacrimal glands produce about 95% of the aqueous component of tears and the accessory lacrimal glands of Krause and Wolfring produce the remainder. Secretion of tears has basic (resting) and much greater reflex components. Reflex secretion occurs in response to corneal and conjunctival sensory stimulation, tear break-up and dry spot formation or ocular inflammation. It is reduced by topical anaesthesia. Although in the past basic secretion was ascribed to the accessory lacrimal glands and reflex secretion to the main lacrimal glands, it is now thought that the whole mass of lacrimal tissue responds as one unit. The precorneal tear film consists of three layers: (a) *lipid*, (b) *aqueous* and (c) *mucin*, each of which has separate functions (Fig. 3.1).

Outer lipid layer

This is secreted by the meibomian glands.

1. Functions
- To retard evaporation of the aqueous layer of the tear film.
- To lower surface tension of the tear film. This, in turn, draws water into the tear film and thickens the aqueous layer.
- To lubricate the eyelids as they pass over the surface of the globe.

2. Dysfunction of this layer may result in an *evaporative dry eye*.

Middle aqueous layer

This is secreted by the lacrimal glands and consists of proteins, electrolytes and water.

1. Functions
- To supply atmospheric oxygen to the avascular corneal epithelium.
- Antibacterial function due to the presence of tear proteins such as IgA, lysozyme and lactoferrin.
- To abolish any minute irregularities of the anterior corneal surface.
- To wash away debris and noxious stimuli and allow the passage of leucocytes after injury.

2. Deficiency of this layer results in a *hyposecretive dry eye*.

Inner mucin layer

This is secreted by the conjunctival goblet cells, the crypts of Henle and the glands of Manz.

1. Function
- Wetting of the cornea by converting the corneal epithelium from a hydrophobic to a hydrophilic surface (Fig. 3.2, right).
- Lubrication.

2. Deficiency of this layer may be a feature of both hyposecretive and evaporative states (Fig. 3.2, left).

The tear film is mechanically spread over the ocular surface through a neuronally controlled blinking mechanism and after a period of time is cleared through the nasolacrimal drainage system. The three factors required for effective resurfacing of the tear film are: (a) *normal blink reflex*, (b) *congruity between the external ocular surface and eyelids* and (c) *normal corneal epithelium*.

Causes

The terms 'dry eye' and 'keratoconjunctivitis sicca' (KCS) are synonymous. The two main categories are: (a) *hyposecretive*, which may be Sjögren or non-Sjögren, and (b) *evaporative*, although the two are not mutually exclusive.

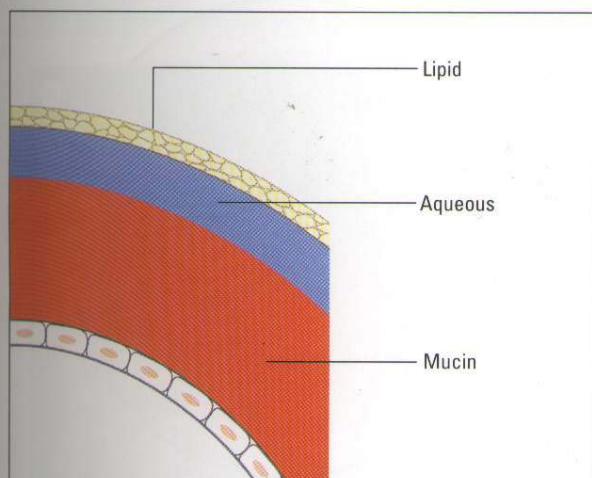


Fig. 3.1
The three layers of the precorneal tear film

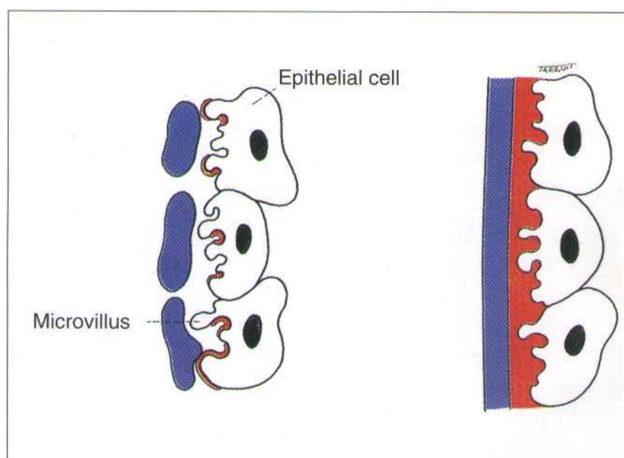


Fig. 3.2
Function of the mucin layer. **(Left)** in mucin deficiency, the aqueous layer (blue) cannot wet the corneal epithelium; **(right)** a normal amount of mucin (red) enables wetting of the corneal epithelium by the aqueous layer

Sjögren hyposecretive KCS

Sjögren syndrome is a cytokine and receptor-mediated inflammatory process that affects the lacrimal gland acini and ducts, leading to abnormalities in the tear film with resultant ocular surface disease.

1. **Primary Sjögren syndrome** is characterized by a dry mouth (xerostomia) and the presence of antibodies indicative of autoimmune pathogenesis.
2. **Secondary Sjögren** is characterized by a systemic autoimmune connective tissue disorder such as rheumatoid arthritis, systemic lupus erythematosus, systemic sclerosis, dermatomyositis and polymyositis, mixed connective tissue disease, relapsing polychondritis or primary biliary cirrhosis, in addition to the features of primary Sjögren syndrome.

Non-Sjögren KCS

1. **Primary age-related** is the most common.
2. **Destruction of lacrimal tissue** by tumour or inflammation (e.g. pseudotumour, thyroid eye disease and sarcoidosis).
3. **Absence of the lacrimal gland** following surgical removal; rarely congenital.
4. **Obstruction of ductules** of the lacrimal gland as a result of severe conjunctival scarring (e.g. cicatricial pemphigoid and trachoma).
5. **Neurological lesions** such as familial dysautonomia (Riley–Day syndrome).

Evaporative KCS

1. **Oil deficiency** is most frequently secondary to obstructive meibomian gland dysfunction (*see* Chapter 1).
2. **Defective resurfacing** of the eye by the tear film as a result of abnormal lid–globe congruity or defective blinking.

Clinical features

Symptoms

The most common are irritation, foreign body sensation, burning, a stringy mucus discharge and transient blurring of vision. Less frequent symptoms include itching, photophobia and a tired or heavy feeling. Patients with filamentary keratitis (*see* below) may complain of severe pain brought on by blinking. Surprisingly, patients seldom complain that their eyes are dry, although some may report a lack of emotional tears or a deficient response when peeling onions. The symptoms of KCS are frequently exacerbated on exposure to conditions associated with increased tear evaporation (e.g. air-conditioning, wind, central heating) or prolonged reading, when blink frequency is reduced. Symptoms may be improved by lid closure.

Tear film abnormalities

1. **Mucus strands and debris** are an early sign. In the normal eye, as the tear film breaks down, the mucin layer becomes contaminated with lipid but is washed away. In the dry eye, the lipid-contaminated mucin accumulates in the tear film and tends to move with each blink. Mucin also has the interesting property of drying very quickly and rehydrating very slowly.
2. **The marginal tear meniscus** is a crude measure of the volume of aqueous in the tear film. The normal meniscus varies in height between 0.1 and 0.5 mm and forms a convex band with a regular upper edge. In KCS the tear meniscus becomes concave, irregular, thin (Fig. 3.3) or absent.
3. **Froth** in the tear film or along the eyelid margin occurs in meibomian gland dysfunction (*see* Fig. 1.33).

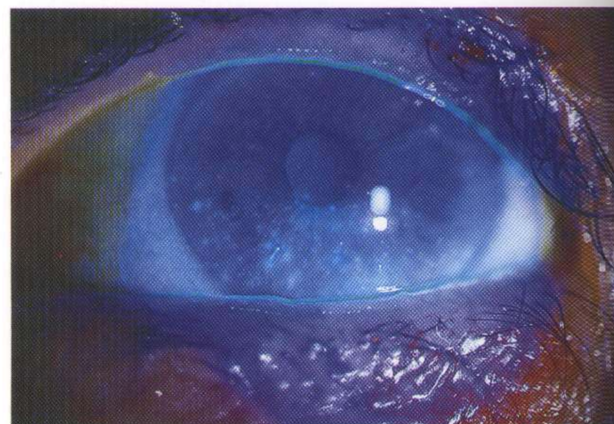


Fig. 3.3
Inferior punctate epithelial erosions stained with fluorescein and a thin marginal tear meniscus in keratoconjunctivitis sicca

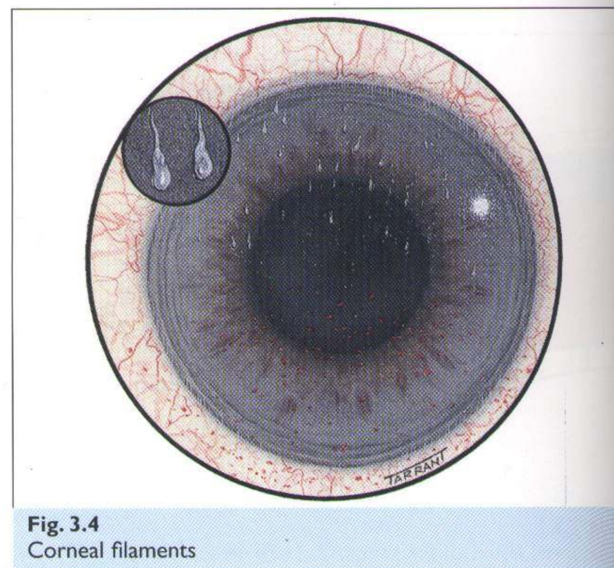


Fig. 3.4
Corneal filaments

Keratopathy

1. **Punctate epithelial erosions** involve the inferior cornea (*see* Fig. 3.3).
2. **Filaments** consist of small, comma-shaped mucus strands lined with epithelium attached at one end to the corneal surface (Fig. 3.4); the unattached end moves with each blink.
3. **Mucus plaques** consist of semi-transparent, white-to-grey, slightly elevated lesions of various sizes and shapes. They are composed of mucus, epithelial cells and proteinaceous and lipoidal material. They are usually seen in association with corneal filaments and both stain with rose bengal (Fig. 3.5).

> *NB:* It should be remembered that a dry eye predisposes to bacterial keratitis and sterile ulceration, which may lead to perforation (Fig. 3.6).

Special investigations

Tear film break-up time

The tear film break-up time (BUT) is an index of precorneal tear film stability. It is measured as follows:



Fig. 3.5
Mucus plaques and a few filaments stained with rose bengal



Fig. 3.7
A dry spot caused by tear film break-up

a. Fluorescein is instilled into the lower fornix.
b. The patient is asked to blink several times and then stop.
c. The tear film is examined with a broad beam and a cobalt blue filter. After an interval of time, black spots or lines indicating the formation of dry areas will appear (Fig. 3.7).

The BUT is the interval between the last blink and the appearance of the first randomly distributed dry spot. The development of dry spots always in the same location should be ignored because this is caused by a local corneal surface abnormality and not by intrinsic instability of the tear film. A BUT of less than 10 seconds is abnormal.

Rose bengal

This dye has an affinity for dead or devitalized epithelial cells and mucus. It stains the exposed bulbar conjunctiva, resulting in the typical staining pattern of two triangles with their bases at the limbus (Figs 3.8 and 3.9). Corneal filaments and plaques are also shown up more clearly by the dye. One disadvantage of rose bengal is that it may cause ocular

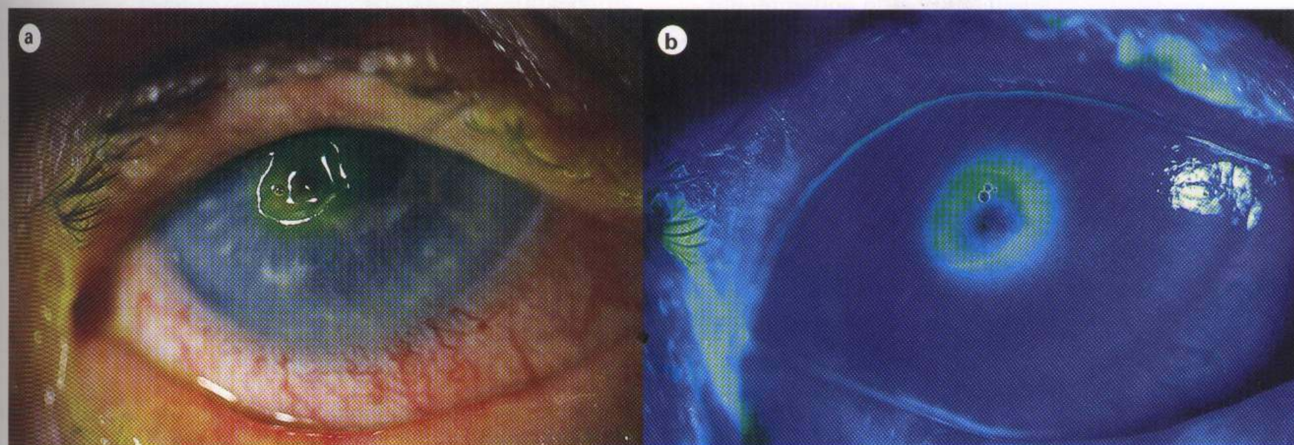
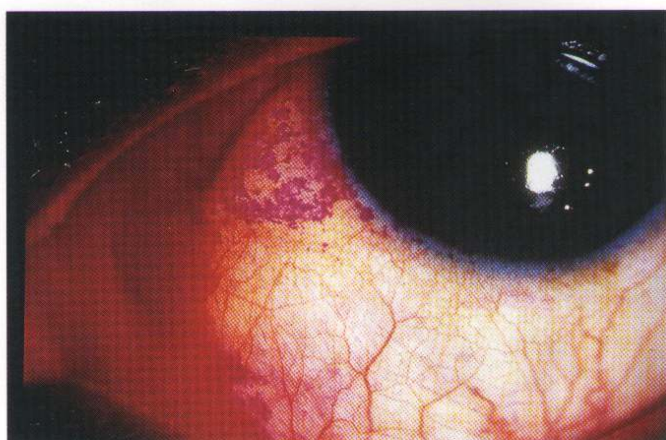
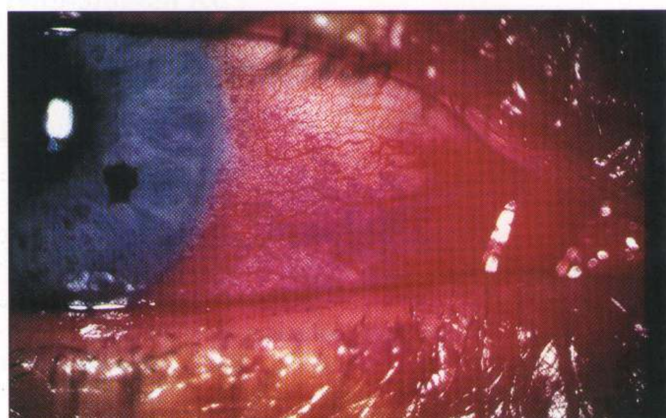


Fig. 3.6
(**a**) Corneal perforation in severe keratoconjunctivitis sicca; (**b**) same eye stained with fluorescein


Fig. 3.8
Mild staining with rose bengal

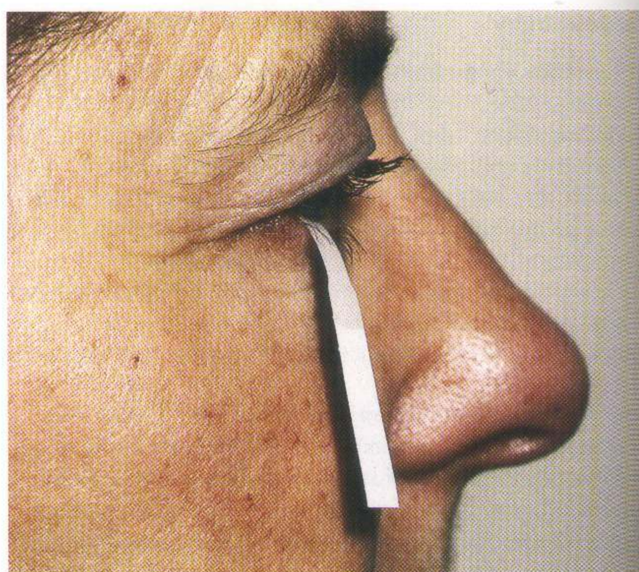

Fig. 3.9
Extensive staining with rose bengal

irritation which can last for up to a day, particularly in severely dry eyes. To minimize irritation a very small drop should be used, but a topical anaesthetic should not be used before instillation because it may induce a false-positive result.

Schirmer test

This is useful when aqueous deficiency is suspected in the absence of slit-lamp signs of KCS. The test involves measuring the amount of wetting of a special (no. 41 Whatman) filter paper, 5 mm wide and 35 mm long. The test can be performed with or without topical anaesthesia. In theory, when performed without an anaesthetic (Schirmer 1) it measures total secretion, basic and reflex, whereas with an anaesthetic (Schirmer 2) it measures only basic secretion. In practice, however, topical anaesthesia reduces reflex secretion but does not abolish it completely. The test is performed as follows:

a. The eye is gently dried.
b. The filter paper is folded 5 mm from one end and inserted at the junction of the middle and outer third of the lower lid, taking care not to touch the cornea.


Fig. 3.10
Schirmer test

c. The patient is asked to keep the eyes open and to blink normally (Fig. 3.10).
d. After 5 minutes the filter paper is removed and the amount of wetting measured.

A normal result is over 15 mm without anaesthesia and slightly less with anaesthesia. Between 6 and 10 mm is borderline and less than 6 mm indicates impaired secretion.

Treatment

The main aims of treatment of KCS are to relieve discomfort, provide a smooth optical surface and prevent structural corneal damage. One or more of the following measures may be used simultaneously.

Preservation of existing tears

1. **Reduction of room temperature**, by avoiding central heating, to minimize evaporation of tears.
2. **Room humidifiers** may be tried but are frequently disappointing because the apparatus is incapable of significantly increasing the relative humidity of an average-sized room. A temporary local increase in humidity can be achieved with moist chamber goggles.
3. **A small lateral tarsorrhaphy** which decreases the surface area of the interpalpebral fissure may be helpful.

Tear substitutes

1. **Drops**
   - Hypromellose (Isopto Plain, Isopto Alkaline, Tears Naturale).
   - Polyvinyl alcohol (Hypotears, Liquifilm Tears, Snotears).
   - Sodium hyaluronate (VISMED, VISLUBE).

- Sodium chloride (Normasol, Steripod Blue).
- Povidone (Oculotet).

NB: The main disadvantages of drops are short duration of action and the development of sensitivity to the preservative (e.g. benzalkonium chloride, thiomersal). The latter can be avoided by using a preservative-free preparation (Minims).

2. **Gels** (Viscotears, Gel Tears) consist of carbomers. In general, they are preferable to drops because they are instilled less frequently.
3. **Ointments** containing petrolatum mineral oil (Lacri-Lube, Lubri-Tears) can be used at bedtime.

Mucolytic agents

Acetylcysteine 5% drops (Ilube) may be useful in patients with corneal filaments and mucous plaques. They are used q.i.d. and may cause irritation following instillation. Acetylcysteine is also malodorous and has a limited bottle life, so that it can only be used for up to 2 weeks.

Reduction of tear drainage

Punctal occlusion preserves natural tears and prolongs the effect of artificial tears. It is of greatest value in patients with severe KCS, particularly when associated with toxicity from preservatives.

1. **Temporary occlusion** of the puncta can be achieved by inserting commercially available collagen plugs into the canaliculi. The main aim of temporary occlusion is to ensure that epiphora does not occur following permanent occlusion. Initially all four puncta are occluded and the patient is reviewed after 1 week. If epiphora is induced, the upper plugs are removed and the patient is re-examined 1 week later. If the patient is now asymptomatic, the plugs are removed and the inferior canaliculi are permanently occluded. Temporary occlusion can also be performed with the argon laser.
2. **Reversible long-term occlusion** lasting several months can be achieved with silicone plugs. Potential problems include extrusion, granuloma formation and distal migration causing inflammation.

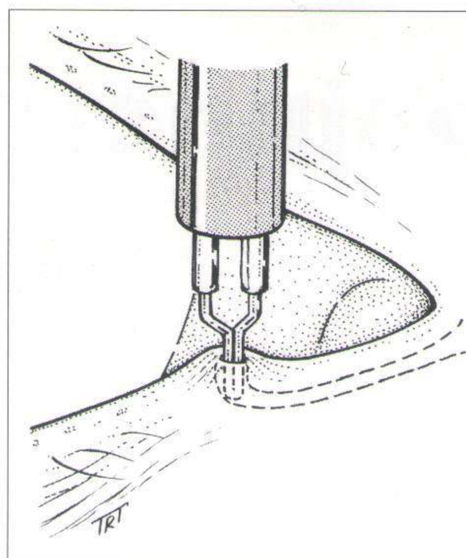


Fig. 3.11
Permanent punctal occlusion

3. **Permanent occlusion** should be undertaken only in patients with severe KCS and repeated Schirmer test values of 2 mm or less. It should not be performed in patients who develop epiphora following temporary occlusion of only the inferior puncta. Permanent occlusion should also be avoided in young patients as their tear production tends to fluctuate. Permanent occlusion is achieved by vigorous punctal dilatation followed by heating for 1 second the mucosal lining of the proximal canaliculus with gentle cautery (Fig. 3.11). Following successful punctal occlusion, it is important to watch for signs of recanalization. It is also important to treat any associated disorder such as chronic blepharitis and superinfection before occlusion.

Other options

1. **Topical cylosporin** (0.05%, 0.1%) is a safe, well-tolerated and effective new medication which reduces cell-mediated inflammation of lacrimal tissue.
2. **Oral cholinergic agents** such as pilocarpine (Salagan) are very effective in the relief of xerostomia and about 40% of KCS patients also obtain relief.